CZ2003: Tutorial 11

Due on April 6, 2021 at 10:30am

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Problem 1

Which three components does the Phong illumination model contain? Which of them will change if one of the followings happens in a scene?

a A light source is moved to a new location.

b The object is moved to a new location.

c The observer is moved to a new location.

Solution
The Phong illumination model contains the 3 components: **Ambient reflection**, **Diffuse reflection** and **Specular reflection**.

$$I = K_a I_a + k_d I_s (N \cdot L) + k_s I_s (V \cdot R)^n$$

If the light source is moved to a new location, Diffuse and Specular reflection would be changed.

If the object is moved to a new location, Diffuse and Specular reflection would be changed.

If the observer is moved to a new location, only the Specular reflection would be changed.

Problem 2

What is the value of the specular exponent for a perfect mirror? Why?

Solution

In a perfect mirror, the concentration of the specular highlight would be high and the highlight would have a sharp drop off,
In this case, the specular exponent would be infinitely high $n = \infty$

Problem 3

A plane is defined by the equation $x + z - 2 = 0$, with the diffuse reflection coefficient 0.5. A point light source with intensity 1 is located at $(10, 10, 10)$. Calculate a diffuse reflection on the plane at point $(1, 10, 1)$.

Solution
The diffuse reflection component of Phong illumination model can be obtained using the following $k_d I_s(N \cdot L)$, where $k_d = 0.5$, $I_s = 1$

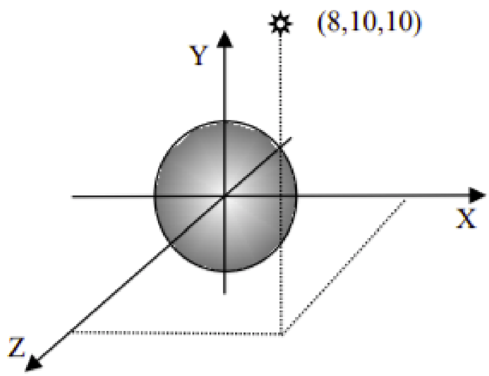
$N = \frac{(A,B,C)}{\sqrt{A^2+B^2+C^2}}$
$N = \frac{(1,0,1)}{\sqrt{2}} = (\frac{\sqrt{2}}{2}, 0, \frac{\sqrt{2}}{2})$

Lighting vector: $L = (10, 10, 10) - (1, 10, 1) = (9, 0, 9)$
After Normalisation, $L = \frac{(9,0,9)}{\sqrt{9^2+9^2}} = (\frac{\sqrt{2}}{2}, 0, \frac{\sqrt{2}}{2})$

Therefore,
$k_d I_s(N \cdot L) = (0.5 * 1)(\frac{\sqrt{2}}{2} * \frac{\sqrt{2}}{2} + \frac{\sqrt{2}}{2} * \frac{\sqrt{2}}{2})$
$= 0.5 * (0.5 + 0.5)$
$= \mathbf{0.5}$

Problem 4

A point light source with intensity 1 is located at coordinates $(8, 10, 10)$. It illuminates an origin-centered sphere with radius 2, diffuse coefficient 0.7, specular coefficient 0.2, and specular exponent 2. The ambient reflection coefficient is 0.1. The intensity of the ambient light source is 1. An observer located at the position with coordinates $(10, 0, 0)$ is looking at a point on the sphere, along the direction $[-1\ 0\ 0]$. Find the point and calculate the illumination on the surface of the sphere at the point seen by the observer.



Solution

$I = K_a I_a + k_d I_s (N \cdot L) + k_s I_s (V \cdot R)^n$
$k_a = 0.1,\ I_a = 1,\ k_d = 0.7,\ I_s = 1,\ k_s = 0.2,\ n = 2$

Observer is looking at point (2, 0, 0) on the sphere.
$\vec{N} = \frac{(2,0,0)}{2} = (1, 0, 0)$

Calculating light vector L:
$\vec{L} = (8, 10, 10) - (2, 0, 0) = (6, 10, 10)$
After normalisation:
$\vec{L} = \frac{(6,10,10)}{\sqrt{236}} = (0.3906, 0.6509, 0.6509)$

Calculating viewing vector V:
$\vec{V} = (10, 0, 0) - (2, 0, 0) = (8, 0, 0)$
After normalisation:
$\vec{V} = (1, 0, 0)$

Calculating reflected vector R:
$\vec{R} = 2(N \cdot L)N - L$
$\vec{R} = 2(0.3906)N - L$
$\vec{R} = 0.7811(1, 0, 0) - (0.3906, 0.6509, 0.6509) = (0.3906, -0.6509, -0.6509)$

Therefore,
$\vec{N} \cdot \vec{L} = (1, 0, 0) \cdot (0.3906, 0.6509, 0.6509) = 0.3906$
$\vec{V} \cdot \vec{R} = (1, 0, 0) \cdot (0.3906, -0.6509, -0.6509) = 0.3906$

$I = 0.1 + 0.7(0.3906) + 0.2(0.3906)^2$
$= \mathbf{0.4039}$